

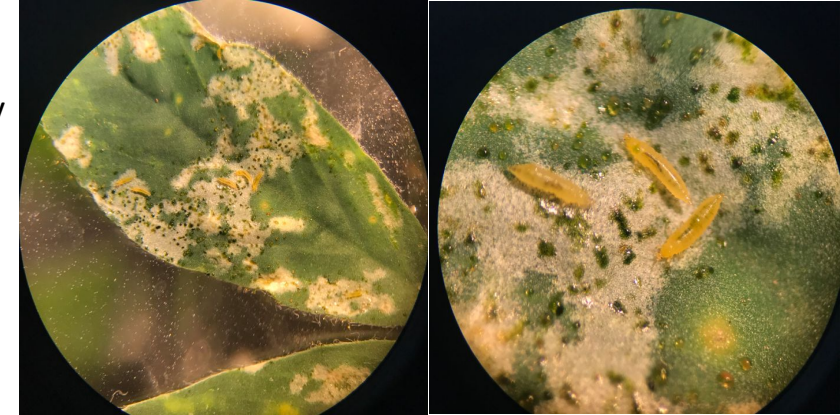
## Spider Mites

- Orange/yellow-orange colored with round body, eight legs, and two spots on their back
- Thrive in dry conditions and when plants are damaged or stressed
- Create very fine but dense webs on tips of foliage with spider mites living in webs
- Around webs are very small, brown spotted patterns in foliage from piercing damage
- Pest Control product to use:
  - Spray directly with hose
  - All Seasons Horticultural Spray
  - Safer Brand Insect Killing Soap
  - Safer 3-in-1 Garden Spray



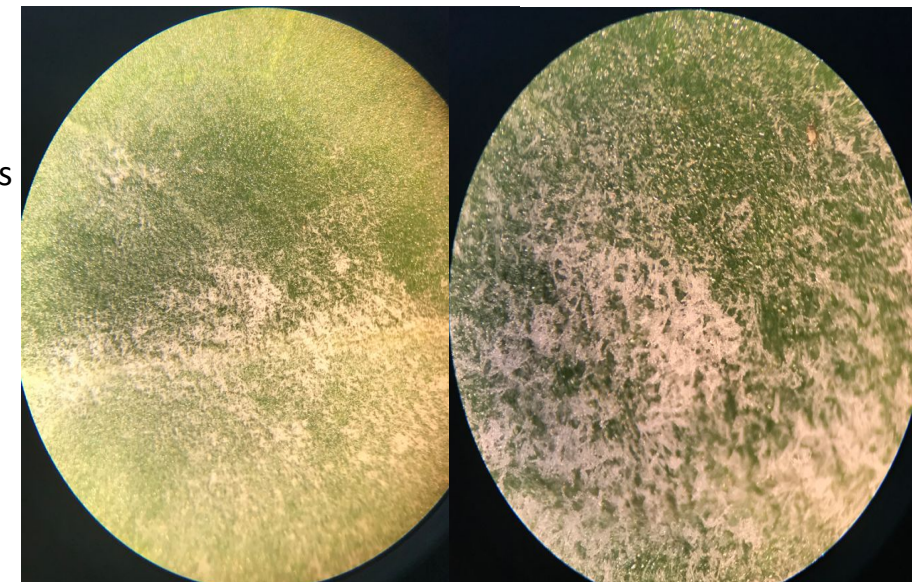
## Thrips

- Long and Slender, earlier stages are yellow and adults are orange with yellow and have wings
- Thrive in warmer environments (peaking at 84 F) and on plants with damage or stress
- Damage is patches of white/gray in the plant foliage from consumption of leaf tissue
- Around/On patches of foliage damage are very small black and yellow dots
- Pest Control product to use:
  - All Seasons Horticultural Spray
  - Safer Brand Insect Killing Soap
  - Safer 3-in-1 Garden Spray



## Powdery Mildew

- White and powdery structure that grows in small patches either covering entire surfaces or in round
- High relative humidity and lower air circulation environments allow powdery mildew to reproduce the best
- Once Powdery Mildew colonizes it has white, powdery growth on leaves, stems, and flowers that will dominate the plants surface area and feed until parts of the plant turn brown, shrivel, and fall off
- Pest Control Product to use:
  - All Seasons Horticultural Spray
  - Safer 3-in-1 Garden Spray



## Aphids

- Oval-shaped body with yellow-green nymphs and gray adults with a slender neck and mouth area
- Normally hard to find but when infested populations clump together and look like mounds
- Thrive in any conditions but reproduce faster in warmer conditions
- Leaf damage hard to find but damage leads to yellowing of leaves. Aphids secrete "honeydew" (Clear/white color) which when left on plants allows sooty mold fungus to form (black with gray spots)
- Pest Control product to use:
  - Spray directly with hose
  - All Seasons Horticultural Spray
  - Safer Brand Insect Killing Soap
  - Safer 3-in-1 Garden Spray



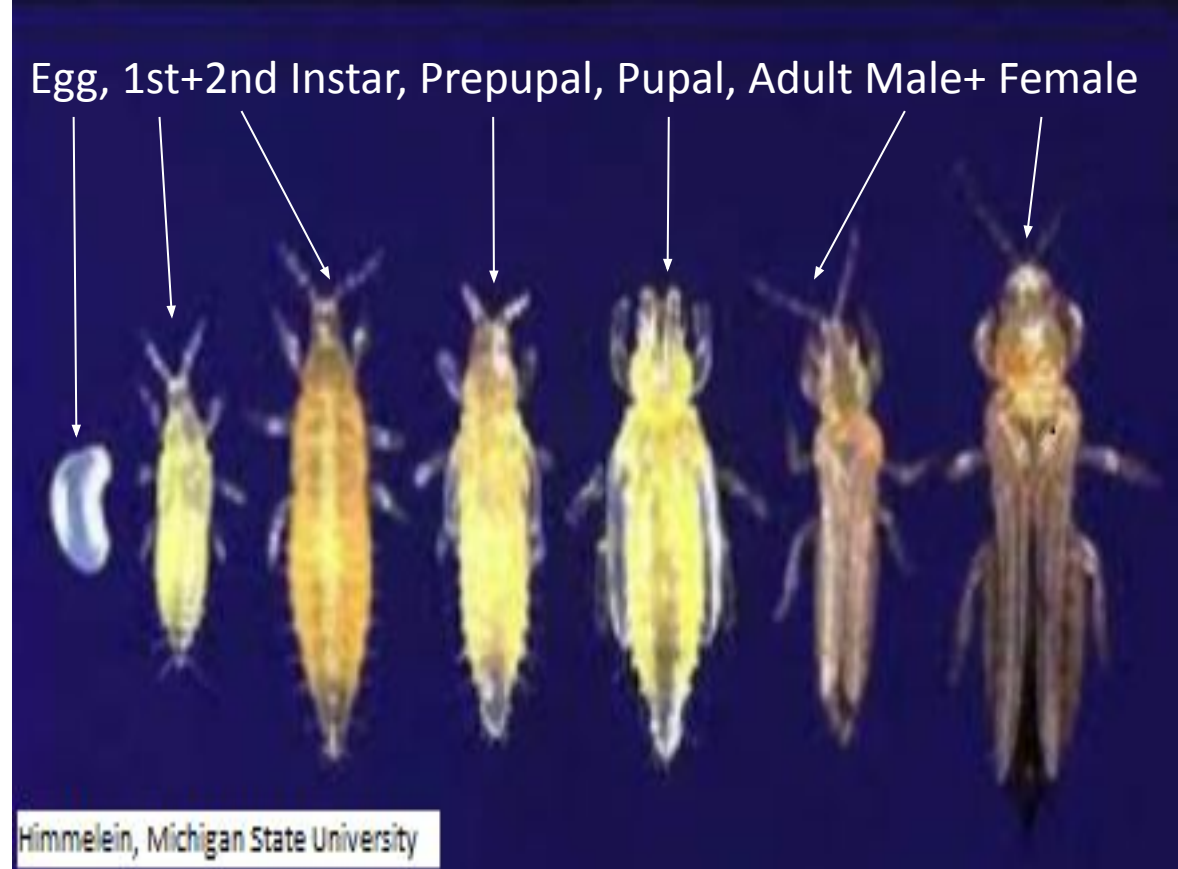
## Fungus Gnats

- Dark brown or black flies that are 1/8 inch long with dark, translucent wings
- Thrive in overwatered soil, primary reason for increased fungus gnat populations
- Damage not noticeable but high counts in soil lead to damage to roots and root hairs
- Pest Control Product to use:
  - Reduce watering
  - All Seasons Horticultural Spray (**Only to soil not foliage**)



# Thrips

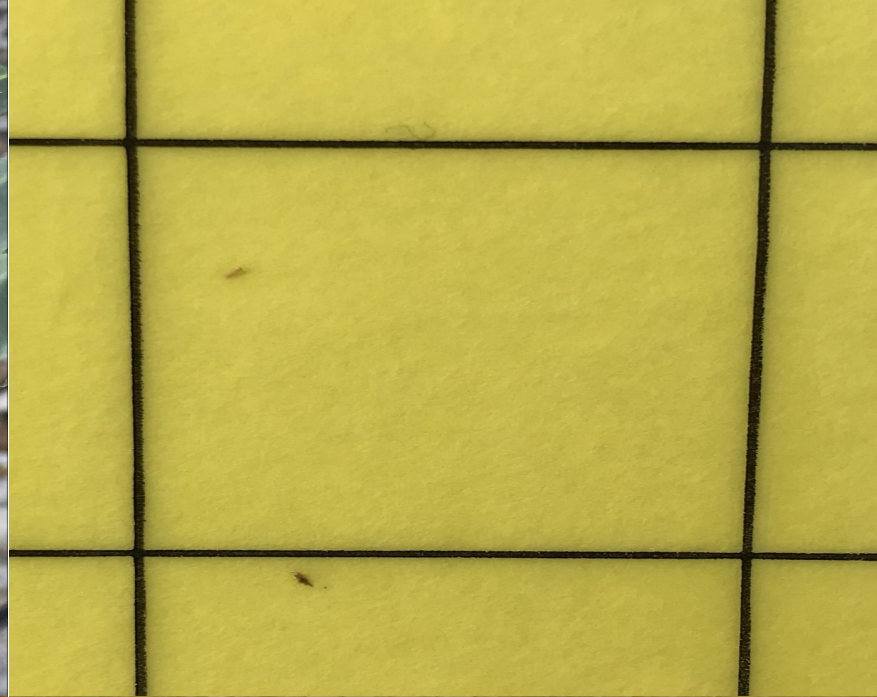
- Life Cycle Stages:
  - Egg – Clear color, laid in leaf tissue (two to four days)
  - First instar – Light yellow coloring with a **feeding stage** (one to two days)
  - Second instar - Yellow-orange coloring still **feeding stage** then drops off plant to surface or lower leaves (two to four days)
  - Prepupal –Yellow, non-feeding drops off plant to growing media or lower leaves (one to two days)
  - Pupal – Yellow color non-feeding stage still in the growing media or lower leaves (one to three days)
  - Adult –Brownish Orange-Yellow/ Orange-Yellow **PEAK feeding stage** and mobile is able to produce up to 300 eggs in adult life (flying or drift in air) (30 to 45 days)
- Between 68-98 F Thrips can grow from egg to adult (develop population) in 7-15 days
- Thrive in warmer environments (peaking at 84 F) and on plants with damage or stress
- Damage is patches of white or pale green with black spots in the leaf foliage from consumption, fecal matter, and laying eggs
- Look for physical pests when damage is seen, Thrips will inhabit top and bottom of leaves and flower foliage



## •Next Steps/ Taking Management Practices:

- Make sure there are signs of active thrips on sticky cards and plant, spray when thrips are seen on plant or sticky card
- Once identified, put on safety glasses and waterproof gloves and apply specific pesticide from the schedule or a different pesticide from what was last used in the specified chamber
- Check the pesticide log in the Excel file "Salk Main Campus Pest Control Log and Counts" to see what was used last to know what not to use, then use pesticide from the schedule or a different product from the "Pesticide Inventory" tab
- Make sure to apply the selected pesticide product to all foliage including leaves, flowers, and stems of plants
  - It is important to get all regions of plant (Upper, Middle, Lower, Interior, and Exterior) with enough application that all surfaces are covered to the point of beading and dripping of pesticide off of leaves
  - Also make sure to apply selected pesticide to the bottom of leaves as well as the top

Thrips



# Spider Mites

- Life Cycle Stages:
  - Egg: Clear and on the bottom of leaves, almost cannot see with naked eye (2 to 3 days)
  - Larva: **Low feeding stage**, colorless for short period then goes under leaf to develop and molt into nymph stage (2 to 5 days)
  - Nymph: **Feeding stage**, color is white with two greenish spots (3 to 8 days)
  - Adult: **Peak feeding stage** appear orange-red or brown and lay 100 eggs in adult life (14 to 28 days)
- Between 55- 98 F can grow, 80 F being most ideal for spider mites productivity, from egg to adult can happen in 8 days
- Thrive in dry and dusty conditions, primarily low humidity and high temperature, also when plants are damaged or stressed
- Create very fine but dense webs on tips of foliage with spider mites living in webs
- Around webs are very small, brown and white spotted patterns in foliage from piercing damage and feces
- Most commonly found at the tips of stems, leaves, and flowers with colonies preferring the highest point on plant
- Also can create webbing in areas within foliage with lower airflow



Mukhopadhyay 2014

## •Next Steps/ Taking Management Practices:

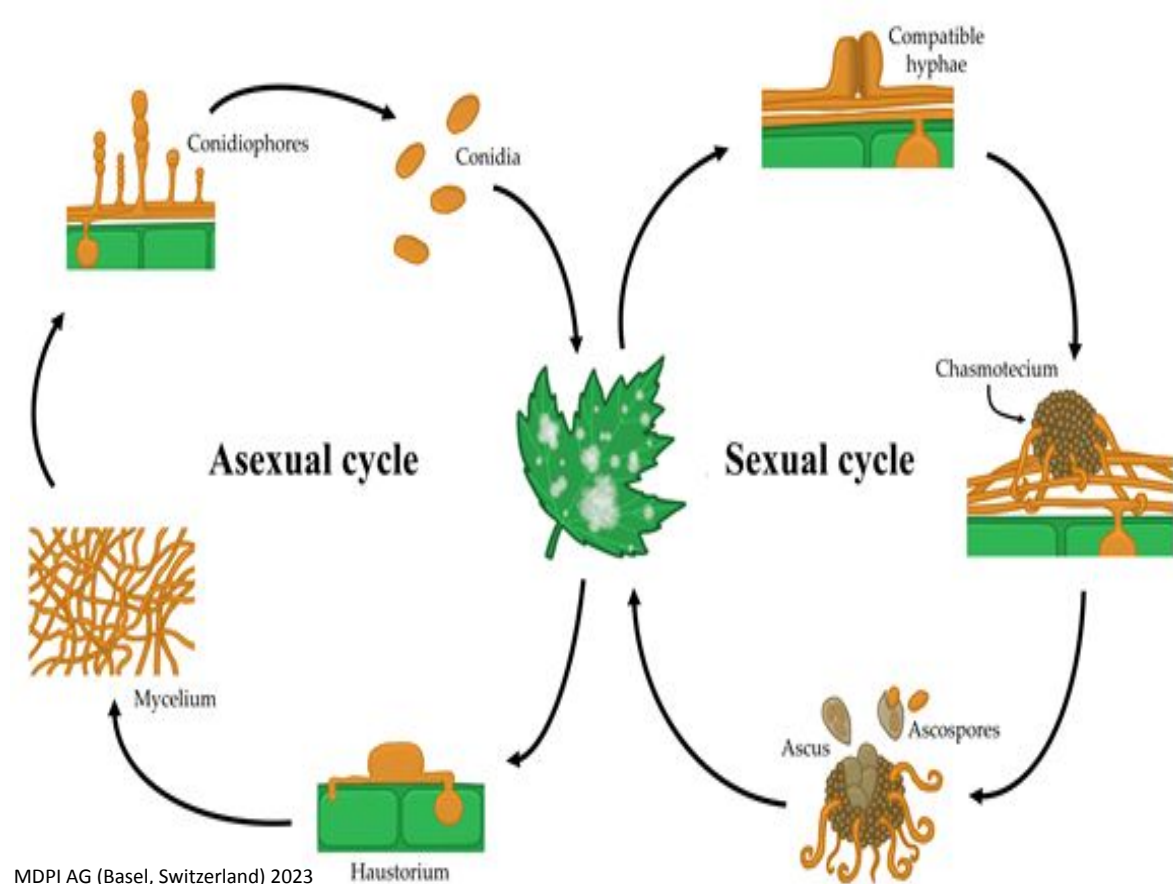
- Make sure there are signs of active spider mites on sticky cards and plant, spray when spider mites are seen on plant
- Once identified, put on safety glasses and waterproof gloves and apply specific pesticide from the schedule or a different pesticide from what was last used in the specified chamber
- Check the pesticide log in the Excel file "Salk Main Campus Pest Control Log and Counts" to see what was used last to know what not to use, then use pesticide from the schedule or a different product from the "Pesticide Inventory" tab
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  - Also make sure to apply selected pesticide to the bottom of leaves as well as the top

Spider Mites



# Powdery Mildew

- Asexual Life Cycle
  - Appressoria: Powdery Mildew spores germinate asexually to form hyphae structures, these structures then grow on the plants surface to create appressoria
  - Haustorium: Once appressoria is developed on the surface hyphal branch structures called haustorium start to develop which allow injection into host cells so that nutrients can be taken from the plant tissue **Feeding Stage**
  - Conidiophores: The development of haustorium colonization on the plants then allows **Peak Feeding** of nutrients from the plant cells so that asexual spores called conidia, which are the building blocks conidiophores, can form which is the white, powdery structure seen when identifying the fungus (weeks to months lifespan)
- Sexual Life Cycle
  - Compatible Hyphae: Powdery Mildew spores germinate sexually to form hyphae structures
  - Chasmodotecium: The hyphae structures colonize plant surfaces creating chasmodotecium which are **feeding stage** fruiting bodies that produce Ascus containing ascospores
  - Ascus and Ascospores: **Peak Feeding Stage** Ascus is the fruiting body that once developed produce ascospores seen by the naked eye and what is identified to be the powdery, white form characterizing powdery mildew (weeks to months lifespan)
- Identified as white and powdery structure that grows in small patches or colonized surfaces either covering entire surfaces or in round, small spots
- High relative humidity, lower temperatures, and lower air circulation environments allow powdery mildew to grow optimally
- Once Powdery Mildew colonizes it has white, powdery growth on leaves, stems, and flowers that will dominate the plants surface area and feed until parts of the plant turn brown, shrivel, and fall off



## Next Steps/ Taking Management Practices:

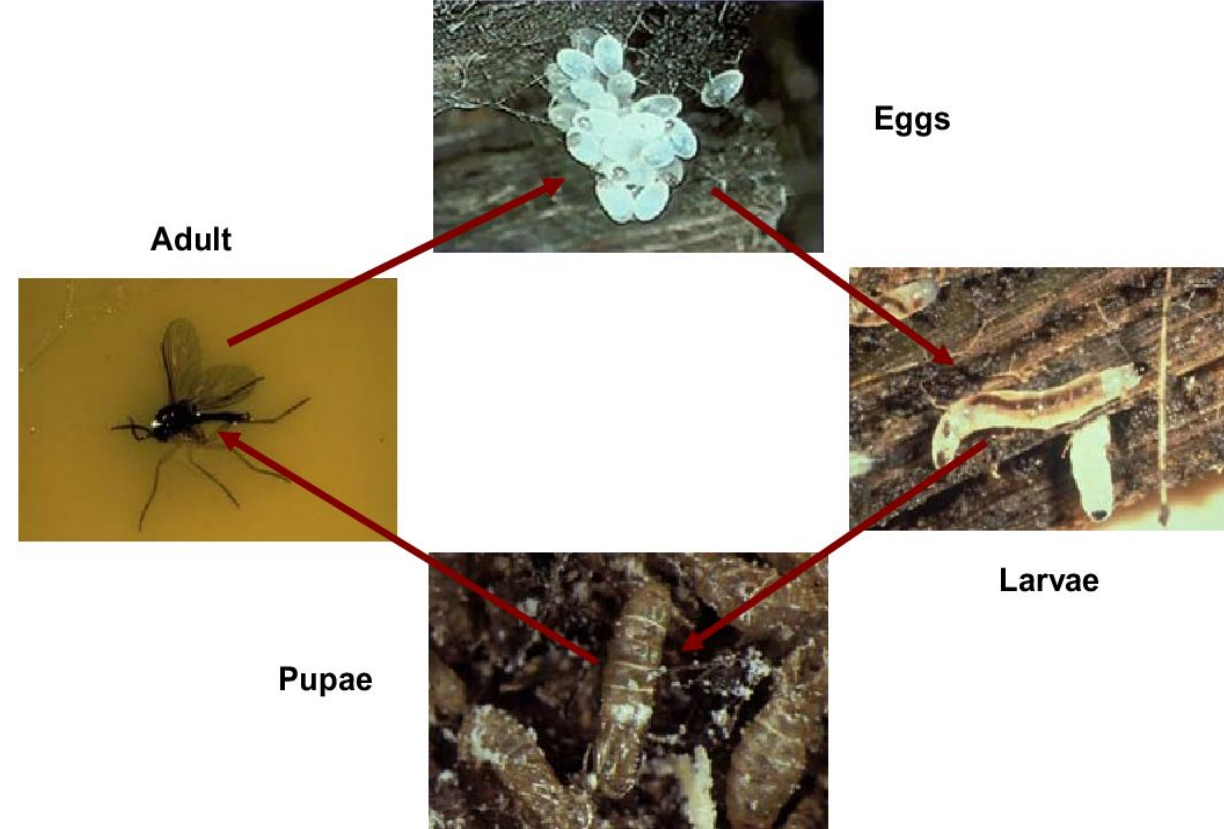
- **Make sure there are signs of powdery mildew on plant, spray when powdery mildew is seen on plant**
- **Once identified, put on safety glasses and waterproof gloves and apply specific pesticide from the schedule or a different pesticide from what was last used in the specified chamber**
- **Check the pesticide log in the Excel file "Salk Main Campus Pest Control Log and Counts" to see what was used last to know what not to use, then use pesticide from the schedule or a different product from the "Pesticide Inventory" tab**
- **Make sure to apply the selected pesticide product to all foliage including leaves, flowers, and stems of plants**
  - **It is important to get all regions of plant (Upper, Middle, Lower, Interior, and Exterior) with enough application that all surfaces are covered to the point of beading and dripping of pesticide off of leaves**
  - **Also make sure to apply selected pesticide to the bottom of leaves as well as the top**
  - **Sanitize pesticide bottle, gloves, and all surfaces touched after application due to high mobility of powdery mildew**

Powdery Mildew



# Fungus Gnats

- Life Cycle Stages:
  - Egg: Non-feeding stage clear eggs that are too small to see (4-6 days)
  - Larvae: **Feeding stage** clear body with black head living in the top layer of growing media eating algae, fungi, and plant roots (12-14 days)
  - Pupae: **Feeding stage** still eating algae, fungi, and plant roots with darker/black body color (4-6 days)
  - Adult: Non-feeding stage black body with slender legs that live on plant foliage and fly short irregular patterns living close to host plant (10 days)
- Optimal reproduction happens at 75 F with an adult that can lay 200 eggs in its life
- Optimal growing conditions in damp/overwatered soil and environments with available algae, dead plant matter, and fungi to eat
- Damage not noticeable but infestation seen by high counts of larvae and adults in/on soil
- Infestation leads to damage at roots and root hairs and fungus gnats are most commonly found in the lower foliage/ growing media region of plant as well can be found in lower counts in upper foliage
- Pest Control Product to use:
  - Reduce watering
  - All Seasons Horticultural Spray (**Only to soil not foliage**)



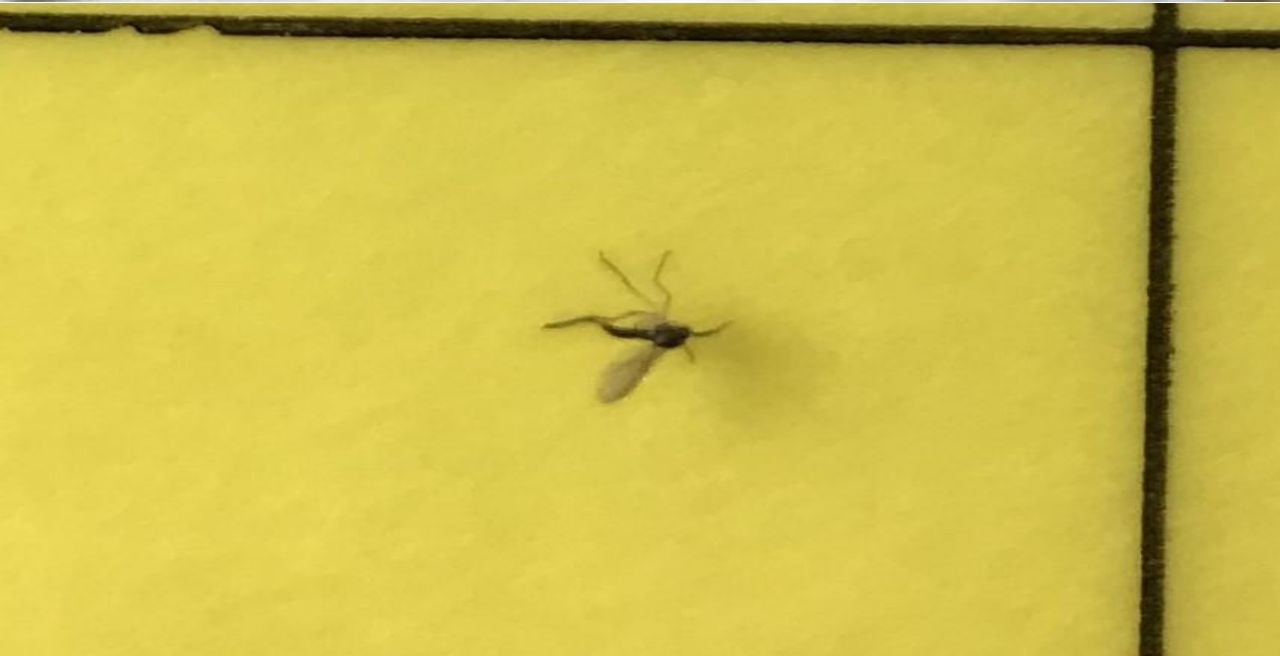
Cycle of fungus gnats (*Bradysia* spp.) from egg to adult.

Cloyd 2009

## •Next Steps/ Taking Management Practices:

- **Make sure there are signs of active fungus gnats on sticky cards and plant, spray when fungus gnats are seen on plant, in growing media, or on sticky cards**
- **Once identified, put on safety glasses and waterproof gloves and apply specific pesticide from the schedule or a different pesticide from what was last used in the specified chamber**
- **Check the pesticide log in the Excel file "Salk Main Campus Pest Control Log and Counts" to see what was used last to know what not to use, then use pesticide from the schedule or a different product from the "Pesticide Inventory" tab**
- **Make sure to apply the selected pesticide product to all foliage including leaves, flowers, and stems of plants**
  - **It is important to get all regions of plant (Upper, Middle, Lower, Interior, and Exterior) with enough application that all surfaces are covered to the point of beading and dripping of pesticide off of leaves**
  - **Also make sure to apply selected pesticide to the bottom of leaves as well as the top**

Fungus Gnats

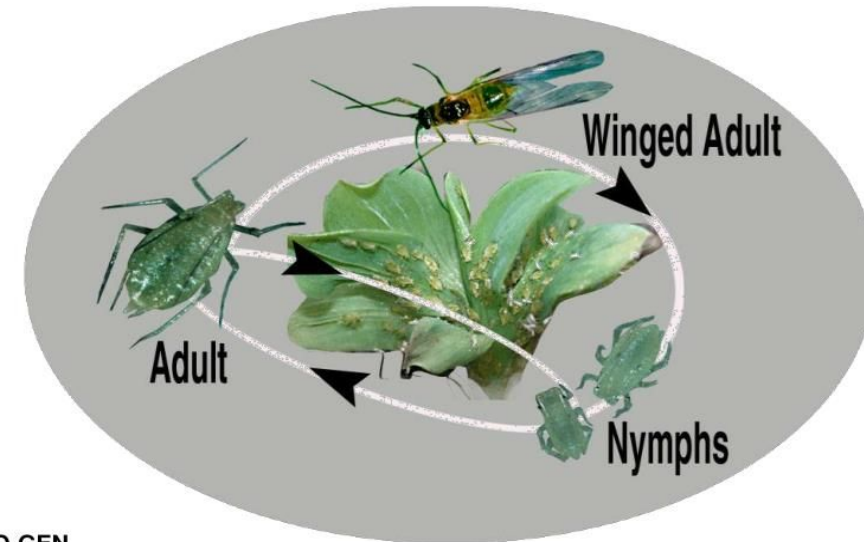


# Aphids

- Life cycle stages
  - Eggs: Non-feeding stage of small, translucent eggs that are only produced from sexual reproduction, most offspring form from asexual production to nymph skipping the egg stage (2 days- months of dormancy)
  - Nymph: **Feeding stage** eating Oval-shaped body with yellow-green nymphs that will molt 4 times before reaching adult stage (2-8 days)
  - Adult: **Peak feeding stage** gray adults with a slender neck and mouth area (that are suited for piercing and sucking plant tissue causing damage to leaves and stems (2-3 weeks)
- Optimal reproduction happens at 65-80 F with an adult that can lay 150-200 eggs in its life, or 12 a day at adult stage
- Normally harder to find but when infested populations clump together and look like mounds on the stems and foliage on the upper and lower sections of the plants
- When infested/ growing populations the adults are established enough to secrete "honeydew" which is a sugary liquid that ants will farm and eat
  - This "honeydew" production will cause a steady attraction of ants and if not taken care of can also lead to sooty mold to grow on the "honeydew" damaging the plant further
- Leaf and stem damage from "honeydew" allows sooty mold fungus to form (black with gray spots) which is the most common way to identify aphid presence other than seeing many aphids forming together covering foliage in large, bumpy clusters
- Pest Control product to use:
  - Spray directly with hose
  - All Seasons Horticultural Spray
  - Safer Brand Insect Killing Soap
  - Safer 3-in-1 Garden Spray

# Aphid Life Cycle

## Nymph to Adult:



©Whitmire Micro-Gen Research Laboratories, Inc. 2002

## •Next Steps/ Taking Management Practices:

- Make sure there are signs of active spider mites on plant, spray when spider mites are seen especially when colonizing**
- Once identified, put on safety glasses and waterproof gloves and apply specific pesticide from the schedule or a different pesticide from what was last used in the specified chamber**
- Check the pesticide log in the Excel file "Salk Main Campus Pest Control Log and Counts" to see what was used last to know what not to use, then use pesticide from the schedule or a different product from the "Pesticide Inventory" tab**
- Make sure to apply the selected pesticide product to all foliage including leaves, flowers, and stems of plants**
  - It is important to get all regions of plant (Upper, Middle, Lower, Interior, and Exterior) with enough application that all surfaces are covered to the point of beading and dripping of pesticide off of leaves**
  - Also make sure to apply selected pesticide to the bottom of leaves as well as the top**

Aphids



# Preventative/ Monitoring

- Scouting
  - Checking on the plants in each growth chamber and any pests that may be living on them is important to get an idea on how to conduct pest management
  - The majority of scouting should be focused on yellow sticky card counts but plants need to be visually inspected for other problems such as powdery mildew, aphids, fungus gnat populations in soil, and other pests that are not apparent on the yellow sticky cards
  - To properly inspect a plant it is important to look closely at the different parts of the plant (leaves, stems, flowers, and seed pods) and regions of the plant (upper foliage, lower foliage, internal foliage hidden in more biomass dense plants)
    - You do not need to inspect every inch of plant surface but looking at multiple parts and regions of each plant is important to get an idea of the average pest pressure on each plant and in the chamber
    - If there is an area of a plant with high pest damage it is important to take extra time to scout the damaged areas to see if there is pests present or if it is damaged foliage with no pests present, this difference will help to see if spraying will be needed
    - Look at approximately 25% of each plants leaves, stems, seed pods, and flowers in the different regions of plants (upper, lower, and internal) to get an in depth scout of current pest pressure without devoting an unnecessary amount of labor to scouting
    - If time is limited for scouting more labor should be focused to sticky card counts and keeping visual inspections short
- Yellow Sticky Traps
  - Sticky traps are an effective form of pest control because they use chromatic attraction to lure pests toward the tape trapping and killing them no matter if these pests have formed resilience to different modes of pest control
  - Make sure to have at least 1 trap set up in each growth chamber set in the most centralized point between the foliage to catch as many pests as possible travelling between plants
  - Make sure to switch out the yellow sticky cards in each chamber every week or before each spray and record the scouting date, type of plant in chamber, and counts of how many thrips are on each card
  - Recording thrip counts over time will be important to see which pesticide control sprays work best and to better modify spraying schedules to be most effective
- Sanitation
  - Keeping surfaces in the growth chambers sanitized is crucial for pest management so that contaminants are not able to thrive leading to plant damage and lowered quality of data
  - Walkways and grow space should be free of soil, organic matter, weeds, and algae; Benches should be disinfected and pots, flats, and trays must be new or disinfected before entering chambers
  - Each grow chamber should be sanitized with diluted physan in a 1 or 2 gallon sprayer to make sure any contaminants or pests present in the previous experiment do not survive and damage future trials in the same chamber

# Management

- Physical Management
  - Keeping the growing chamber sanitized and free of algae, leaf litter, and fungi will be crucial to maintaining preventative management to reduce spraying and scouting
  - Make sure to check first with person whose running experiment if you can remove damaged foliage
  - If pests have heavy presence/infestation on a plant it is important before spraying to remove damaged or infected foliage from the plant with pruners and put into plastic bags that are sealed then removed from growth chamber and properly disposed of
  - After using pruners make sure to spray with disinfectant and wash thoroughly immediately after use to prevent contamination
- Pest Control Product Inventory
  - All Seasons Horticultural Spray (Pesticide)
  - Safer Brand Insect Killing Soap (Pesticide)
  - Safer Brand 3-in-1 Garden Spray (Pesticide)
  - Physan (Chamber Sanitization)
  - Yellow Gridded Sticky Cards with card holders and cups to stabilize (Trap and Scouting Tool)
- Spraying Schedule
  - Use schedule for pesticide applications over time that consists of a variety of products, pesticides have different modes of action that terminate pests using different methods of termination and cycling between products will prevent pest resistance to specific pesticides over time
  - On an excel sheet keep a pesticide spray log with date, product used, pest targeted, and chamber sprayed so that data can be built to see which pesticides are and are not effective to ensure cycling of effective products to prevent chemical resilience from pest populations in growth chambers
  - From the Pest ID sheet use only one method of control per treatment and make sure to spray each plant thoroughly until pesticide runs off making sure to cover:
    - all leaves, stems, flowers, and seed pods
    - Upper, middle, and lower regions of plant
    - Outer foliage and inner foliage hidden within or behind the exterior plant matter
    - Bottom side of leaves important for full coverage
  - Make sure to follow all pesticide labels closely so that you know what PPE, spraying instructions, and intervals between sprays need to be followed for most effective use of products
  - Before or after each spray application make sure to update the pesticide log so when thrip population counts are collected over time you can see what products work most effectively in knocking down thrips populations
  - As time passes and thrip counts are recorded over time, make sure to analyze and interpret the graphs to see which pesticides need to be used, removed from usage, or if other products need to be tried

- Pesticide Log And Sticky Card Scouting Data

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